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7N AEB
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GB 1513981
GB 1510548
GB 1510033
GB 1502697
GB 1496976
GB 1476758
GB 1146950
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GB 1122763
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(58) Field of search
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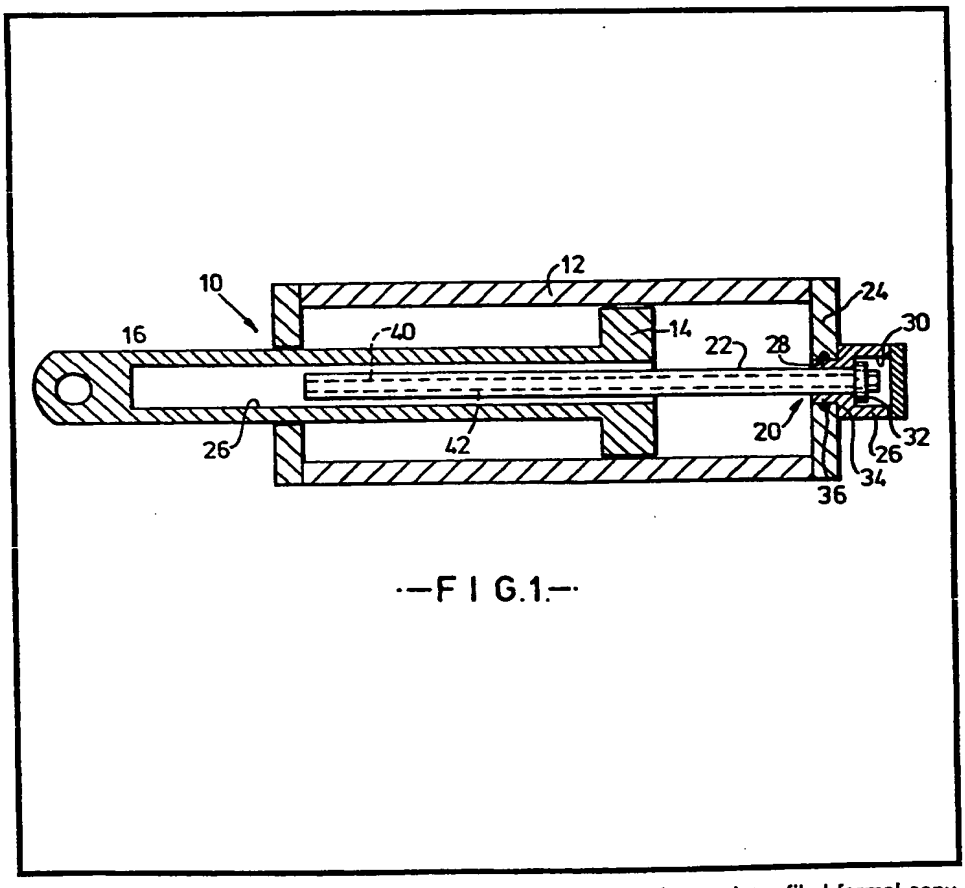
Roystons

(54) Distance measuring

(57) A transducer for measuring relatively large displacements between relatively movable parts of apparatus, such as the piston (14) and cylinder (12) say of a hydraulic ram (10) comprises as or fixed to one such part an elongate transducer element (20) carrying primary (40) and secondary (42) windings wound longitudinally thereof to generate a magnetic field into or in which the other of the relatively movable parts is movable to vary the magnetic intercoupling between the primary and secondary windings. The other part may be a part of the transducer or of the apparatus itself. Thus, in an hydraulic ram the elongate element may be fixed relative to a cylinder end wall (24) to extend into a longitudinal bore (26) of the piston. Or the bore may be fitted with a sleeve.



—F I G.1.—

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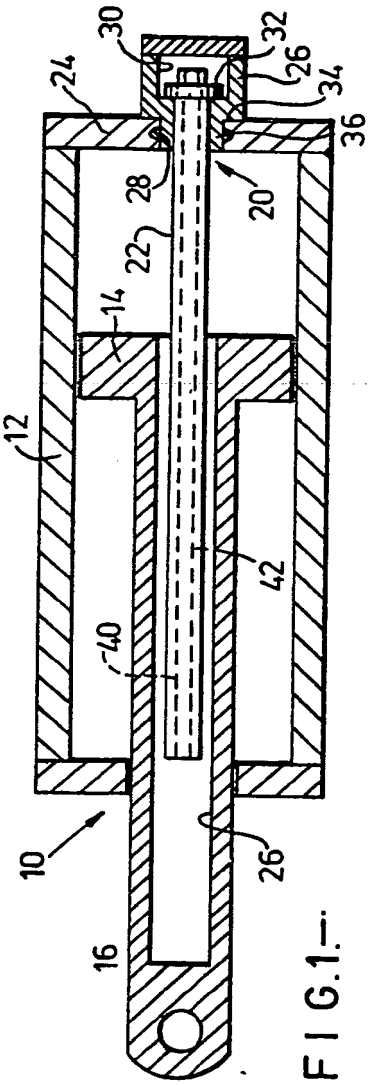
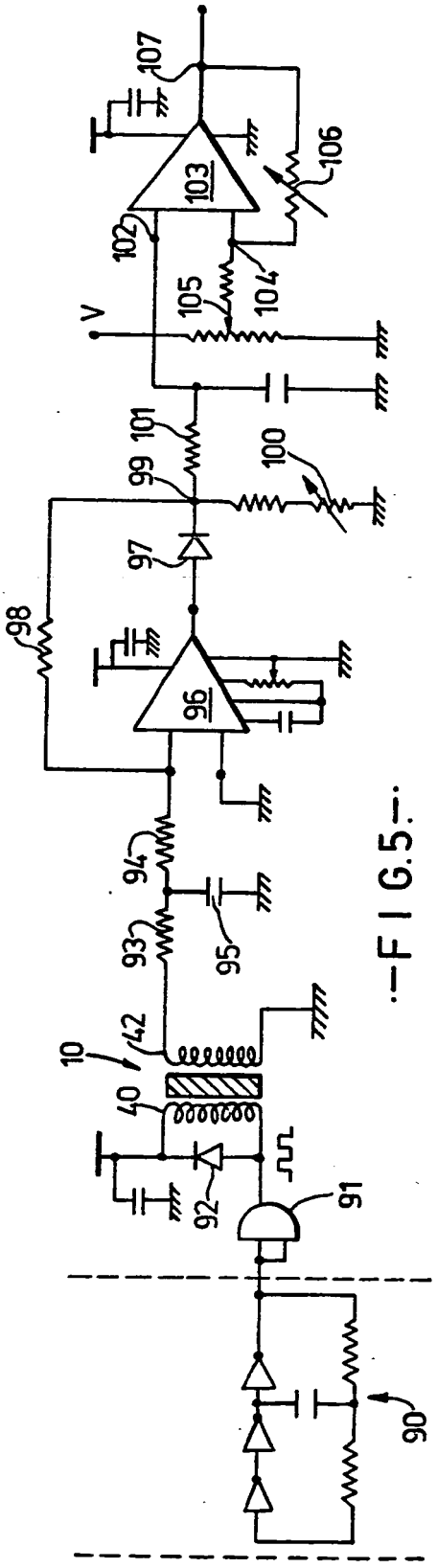


-FIG.1-



-FIG.5-

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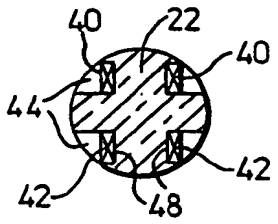
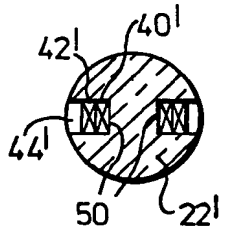
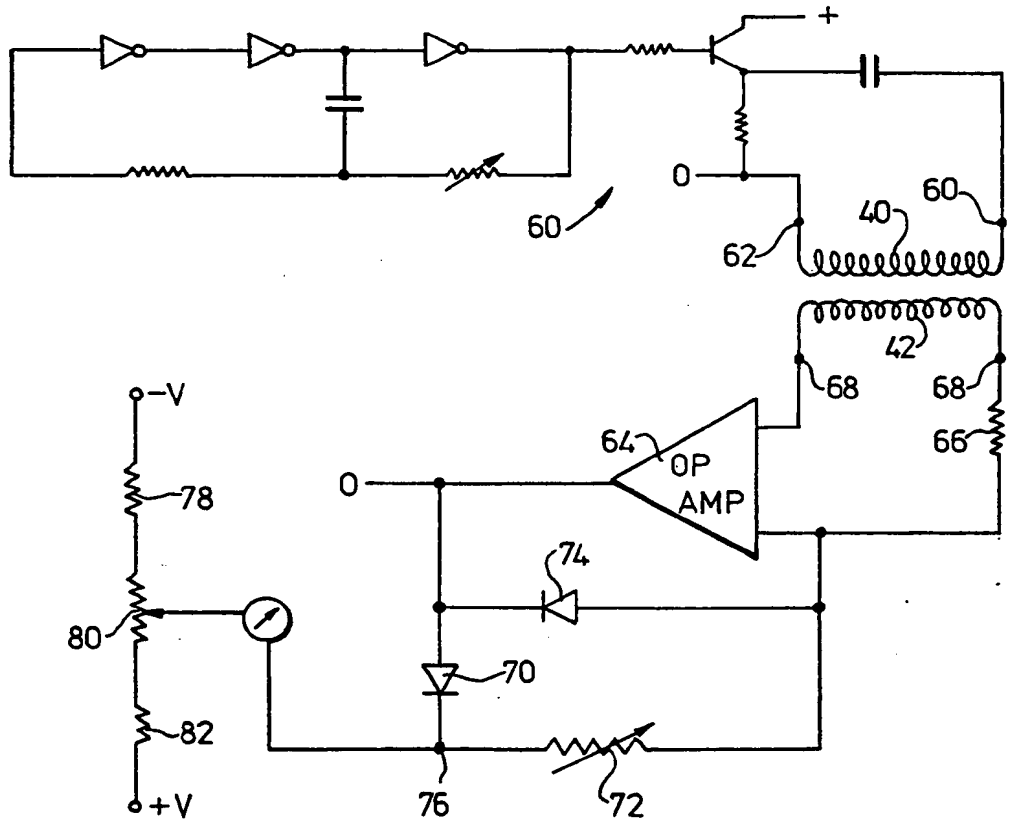


-FIG.2-



-FIG.3-



-FIG.4-

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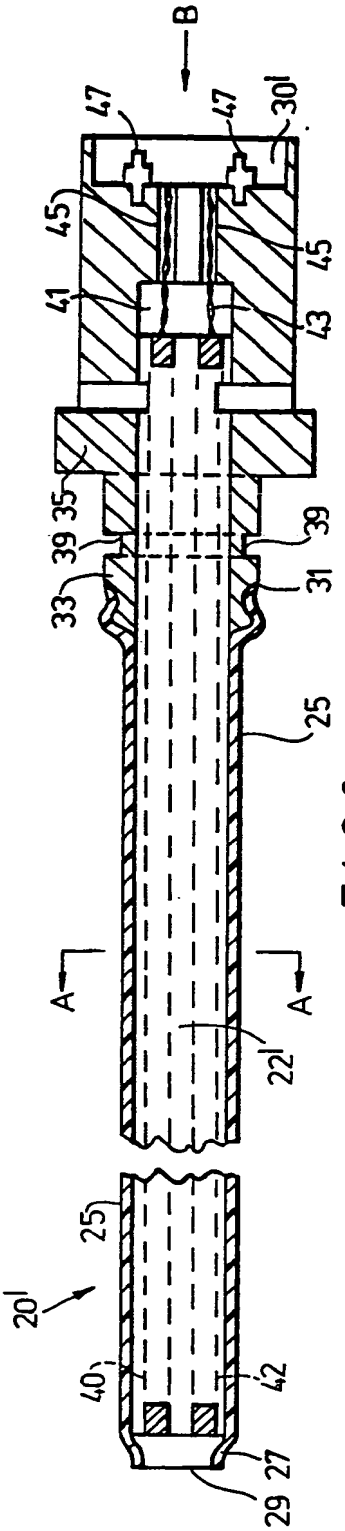
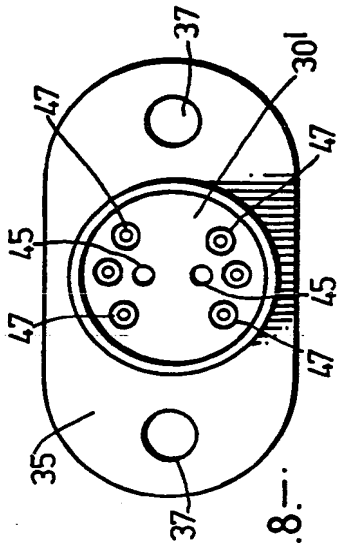
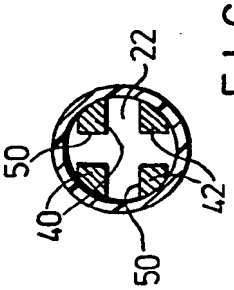


-FIG.6.-



-FIG.8.-



-FIG.7.-

SPECIFICATION

Distance measuring

The invention relates to distance measuring and particularly to transducers for use in measuring substantial relative distance displacements between parts of apparatus, for example hydraulic rams.

One known type of distance transducer comprises an iron core axially movable within a tubular coil carrier having primary and secondary windings so as to influence secondary windings output according to the axial position of the core when the primary winding is energised by a given waveform. For small relative displacements of a few millimetres such transducers are fairly compact, typically requiring only a central primary coil winding and flanking secondary windings usually connected to supply a difference signal from which the relative displacement is readily and accurately derived, say in a bridge circuit. However, such transducers are less satisfactory for incorporating in apparatus and measuring larger displacements, such as up to 300 mm or more, even when provided with more windings, as there is generally a much larger length of transducer than the distance to be measured.

To this end, we provide as or fixed to one of relatively movable parts an elongate transducer element carrying primary and secondary windings wound longitudinally thereof to generate a magnetic field into or in which another of said relatively movable parts is movable to vary the magnetic intercoupling between the primary and secondary windings. The other of the relatively movable parts may be a second part of the transducer, or often an apparatus part itself, coupled for axial displacement relative to the element to provide detectable output differences. Preferably the other part is, of magnetic material.

In one embodiment, the other part i.e. the second transducer part or apparatus part is a tube or has a tubular cavity or bore overfitting the transducer element to variable axial extents. Clearly, however one or more discrete parts of magnetic material could be used, perhaps especially if a direct digital output was required, when steps corresponding to a plurality of discrete spaced such parts could simply be counted with or without integration between them to give a finer resolution according to phase or level between known limits intermediate steps.

A particular preferred transducer element comprises a rod-like member, preferably of non-remanent magnetic material, longitudinally slotted to carry primary and secondary windings in separate slits or superposed in the same slot or slots.

In application to a hydraulic ram the transducer element may be fixed relative to a cylinder end wall to extend into a longitudinal cavity or bore in the piston so that the piston, itself, usually together with its connecting rod or thrust bar, will extend into the flux closure paths and thus modify the magnetic field externally intercoupling the windings, so affecting output from the secondary winding according to ram extension. If preferred, the interior of the cavity or bore could be sleeved or otherwise carry a specific second transducer part or parts for modifying flux closure paths or otherwise detectably affecting the secondary winding output on energisation of the primary winding.

The primary winding or windings will usually be energised with an alternating, preferably square waveform, signal and in preferred embodiments the corresponding output of the secondary winding or windings is rectified, conveniently by a full wave rectifier incorporating a feedback amplifier to give a unidirectional output signal. Preferably means is provided for offsetting this output signal relative to a predetermined reference level, for example corresponding to a corresponding, say extreme; relative displacement of the relatively movable parts.

Specific implementation of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a longitudinal section of a hydraulic ram fitted with a distance transducer;

Figure 2 is a cross-section of an element of the transducer of Fig. 1;

Figure 3 is a cross-section of a variant of the element of Fig. 3;

Figure 4 shows circuit diagram details of one convenient energisation and detection arrangement for an analogue output;

Figure 5 is a circuit diagram showing details of an alternative circuit;

Figure 6 is a longitudinal section showing the transducer element in more detail;

Figure 7 is a cross-section on the line AA of Fig. 6; and

Figure 8 is an end view of the transducer element.

In Fig. 1, a hydraulic ram 10 having a cylinder 12, piston 14 and integral connecting rod or thrust bar 16 is shown fitted with a distance transducer element 20 comprising an elongate member or rod 22 extending into the cylinder 10 from end wall 24 thereof and into a cavity or blind bore 26, shown as being axial, but not necessarily so, in the piston 12 and its connecting rod or thrust bar 15. The member 22 is secured relative to the cylinder end wall 24 in any convenient way, specifically via a transducer body part 26 fitted in and sealed relative to through-hole 28 in the end wall 24 and having an internal chamber 30 having a seating part 32 for the member 22 preferably adjustable axially therealong,

say by mating threads. Obvicusly, the member could be secured directly into the neck part 34 of the body part if desired.

The elongate member 22 carries lengthwise thereof primary and secondary windings 40 and 42 laid into longitudinal slotting thereof and sealed off with any suitable material 44, such as epoxy resin that will withstand penetration by pressurised hydraulic fluid. Fig. 2 shows separate lengthwise slotting 46 and 48 for the primary and secondary windings 40 and 42, respectively, whereas Fig. 3 for variant member 22' shows superposed primary and secondary windings 40' and 42' in common slotting 50.

Figs. 6, 7 and 8 show an alternative form of transducer element 20' comprising an elongate member or rod 22', of mild steel, having longitudinally wound primary windings 40 and secondary windings 42 each housed in a respective one or four longitudinal slots 50.

The windings are impregnated with epoxy resin or the like and laid upon cloth similarly treated. Ingress of contaminant such as hydraulic fluid is prevented by a nylon sleeve 25 heat shrunk onto the elongate member 22' and extending between a circumferential terminating groove 27 in a steel disc 29 bonded to the innermost end of the member after winding and a similar groove 31 in an enlarged portion 33 towards the opposite end of the member. Adjacent the enlarged portion is a radial flange 35 with holes 37 whereby the member can be secured to the cylinder wall 24 (see Fig. 1) with the elongate portion extending into the cylinder, and a circumferential groove 39 is provided between groove 31 and flange 35 to accommodate a sealing ring to seal the element to the through hole 28 (see Fig. 1).

The windings, and grooves, extend through the enlarged and flanged portions of the element into a cavity 41 from which connecting leads 43 pass through axial holes 45 to connect the windings to respective terminals 47 in a recess or terminal chamber 30' at the end of the element. The cavity 41 is filled with epoxy resin or the like after the connections have been made.

In operation, assuming the piston 14 and its connecting rod or thrust bar 16 to be of suitably magnetic material, the magnetic coupling between the primary and secondary windings will vary according to the position of the piston 14 and in a substantially linear manner. If the piston 14 and its connecting rod or thrust bar 16 are not suitable for the purpose, a sleeve of magnetic material may be inserted therein either permanently or removably. Alternatively or additionally, specific, discrete magnetic members or parts may be mounted at intervals along the cavity or bore or in a sleeve or on any other desired carrier so as to give a step type secondary output.

However, as shown, a suitable analogue output may be obtained for a varying input, preferably but not necessarily of regular sine wave form, to the primary winding at low current and a voltage level of 6 volts or less, making it easy to render the transducer suitable for use where intrinsic safety requirements prevail, e.g. in coal mines for advancing rams of self-advancing mine-roof supports or their props, especially where accurate data is required for automatic face working control. Digitising an analogue output is readily achieved or digital circuitry may be used to give a direct digital output. Fig. 4 shows one suitable form of supply and detection circuitry where 60 represents a commercially available CMOS type oscillator design delivering a square waveform at output terminator 62 connected to primary winding 40. Detection circuitry is in the form of a halfwave rectifier utilising an operational amplifier 64 having its inputs connected, one via resistor 66, to secondary coupled terminals 68. The output of the operational amplifier 64 is connected to its resistor-fed input via a feed-back path including diode 70 and variable resistor 72 to give a desired gain, that feedback path being bridged by rectifying diode 74. The junction 76 of diode 70 and variable resistor 72 is used as the detector output but is shown subject to an offsetting or zero-setting variable resistor chain 78, 80, 82, preferably subject to an indicator or meter to permit adjustment as desired.

Fig. 5 shows an alternative circuit in which an oscillator 90 supplies a 2KHz signal to driver 91 which converts the signal to a square wave and applies it to the primary winding 40 of the transducer 10 across which is connected diode 92. The secondary winding 42 of the transducer 10 is connected by way of a T-network comprising resistors 93, 94 and capacitor 95, to an amplifier 96 which, as in the circuit of Fig. 4, has a feedback loop including diode 97 and resistor 98 and so functions as a full-wave rectifier, the output of which is taken from the junction 99 between the diode 97 and resistor 98. A variable resistor 100 connected between junction 99 and ground serves to adjust the output level of the rectifier.

The output of the rectifier is connected via resistor 101 to one input 102 of a differential amplifier 103. The other input 104 of the amplifier 103 is connected to a potentiometer 105 and by way of a variable feedback resistor 106 to the amplifier output 107. A reference voltage V_{REF} is applied across potentiometer 105 so that adjustment of the potentiometer will bias or offset the output signal from amplifier 103, and hence the circuit, relative to a predetermined level and adjustment of feedback resistor 106 will adjust the gain of the amplifier and hence the output signal amplitude.

Normally, of course, all electronic supply

and detection circuitry will be housed in the transducer body chamber 30 and 30', usually on a single printed circuit board so that only low level input and output terminals will be required thereat.

Clearly, any desired output may be readily obtained by electronic matching circuits serving to translate signal levels to interface with any other desired equipment should the obtainable levels differ. Otherwise, of course, purpose designed output circuitry could be designed.

It will be appreciated that windings wound longitudinally of the transducer element will provide a substantial "leakage" flux path in the air or fluid around the element, and variation of the reluctance of the path by the relatively movable part will produce a significant output signal change more efficiently compared with known elements having coils wound around the circumference of the element and without complex winding configurations.

CLAIMS

1. A transducer for use in measuring displacements between relatively movable parts comprising as or fixed relative to one part an elongate transducer element carrying primary and secondary windings wound longitudinally thereof to generate a magnetic field into or in which another of the relatively movable parts is movable to vary the magnetic intercoupling between the primary and secondary windings.

2. A transducer as claimed in claim 1, wherein the elongate element comprises a rod-like member and said other part is annular, recessed or tubular to accommodate at least a substantial portion thereof.

3. A transducer as claimed in claim 1 or 2, wherein the said other part is of or includes magnetic material.

4. A transducer as claimed in claim 1 or 2, wherein the elongate element has at least one longitudinal groove housing at least one winding.

5. A transducer as claimed in claim 4, wherein the or each groove houses a primary winding and a secondary winding.

6. A transducer as claimed in any preceding claim, further comprising means for applying an alternating signal to the or each primary winding and means for deriving from the or each secondary winding a signal representative of relative displacement of the parts.

7. A transducer as claimed in claim 6, wherein the means for applying comprises an oscillator.

8. A transducer as claimed in claim 7, wherein the means for applying comprises means responsive to output from an oscillator to supply a square waveform signal for application to the or each primary.

9. A transducer as claimed in claim 6, 7 or 8, wherein the means for deriving comprises means responsive to alternating output from the or each secondary winding to provide a unidirectional output signal.

10. A transducer as claimed in claim 9, wherein the means for providing the unidirectional output signal comprises a full wave rectifier.

11. A transducer as claimed in claim 10, wherein the rectifier comprises an amplifier having a feedback loop including a unidirectional conduction device.

12. A transducer as claimed in claim 9, 10 or 11, wherein the means for deriving comprises means for offsetting the unidirectional output signal relative to a predetermined reference level.

13. A transducer as claimed in claim 12, wherein the offsetting means comprises a differential amplifier having one input connected to receive the unidirectional output signal and its other input connected to a reference voltage source variable to offset the differential amplifier output.

14. A transducer for use in measuring substantial relative distance displacements substantially as herein described with reference to and as shown in Figures 1 to 4 and 5 to 8 of the accompanying drawings.

15. A hydraulic ram including a transducer as claimed in any preceding claim with the elongate transducer element fixed relative to a cylinder end wall to extend into a longitudinal cavity or bore in the piston.

16. A hydraulic ram as claimed in claim 15, wherein the said other relatively movable part comprises a sleeve in the longitudinal cavity or bore.

17. A transducer element substantially as herein described with reference to and as shown in Figs. 1, 2 and 3 or Figs. 6, 7 and 8 of the accompanying drawings.

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EUROPEAN PATENT OFFICE

Patent Abstracts of Japan

PUBLICATION NUMBER : 63067411
PUBLICATION DATE : 26-03-88

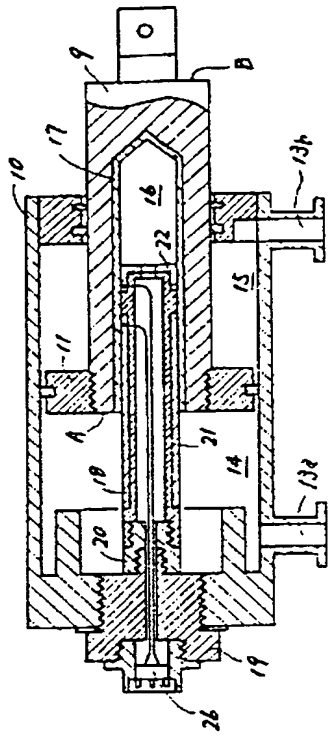
APPLICATION DATE : 10-09-86
APPLICATION NUMBER : 61213408

APPLICANT : KUBOTA LTD;

INVENTOR : EMA HIROAKI;

INT.CL. : F15B 15/28 G01B 7/00

TITLE : STROKE SENSOR BUILT-IN TYPE CYLINDER



ABSTRACT : PURPOSE: To improve reliability by jointing an insulation layer composed of dielectric material to the recess of a piston, and jointing a fixation side electrode to an inner cylinder main body which is supported by a cylinder and inserted into the recess.

CONSTITUTION: A recess 16 is formed on a movable portion 12 of a piston 11, and an insulation layer 17 composed of dielectric material is jointed on the surface of the recess 16. An inner cylinder body 21 inserted into the recess 16 is fixed to a cylinder 10, and a fixation side electrode 18 is jointed to the surface of the inner cylinder main body 21. An electrostatic capacity type stroke sensor can thus be built in the piston cylinder 10, thereby reliability in usage under bad conditions can be improved.

EUROPEAN PATENT OFFICE

Patent Abstracts of Japan

PUBLICATION NUMBER : 05018406
PUBLICATION DATE : 26-01-93

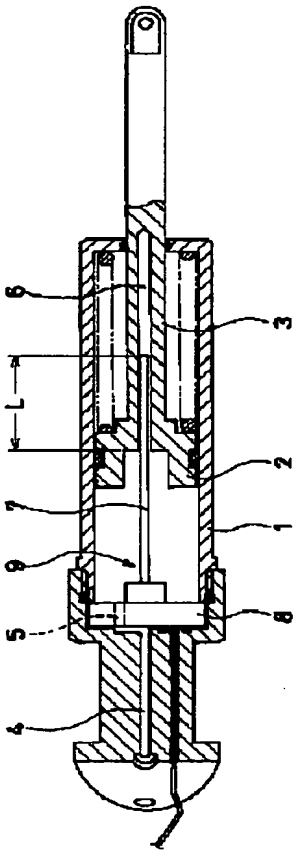
APPLICATION DATE : 11-07-91
APPLICATION NUMBER : 03170948

APPLICANT : YAMAHA MOTOR CO LTD;

INVENTOR : IWAMOTO TADAMITSU;

INT.CL. : F15B 15/28 G01B 7/00

TITLE : OIL-HYDRAULIC APPARATUS WITH STROKE SENSOR



ABSTRACT : PURPOSE: To construct a device concerned in a compact size by installing a built-in stroke sensor in a hydraulic apparatus.

CONSTITUTION: A rod sensor 7 with a solenoid A fitted internally is fixed to the bottom surface of a cylinder 1 in such a way as stretching in the cylinder axial direction, and a piston rod 3 is made from a non-magnetic or a feeble magnetic substance. A measuring hole 6 opening to the piston 2 side is provided in the axis of the piston rod 3, and in this hole the rod sensor 7 is inserted with possibility of relative movement. The stroke amount of the piston 2 is sensed from the overlapping length of the rod sensor 7 and hole 6.

EUROPEAN PATENT OFFICE

Patent Abstracts of Japan

PUBLICATION NUMBER : 58225205
PUBLICATION DATE : 27-12-83

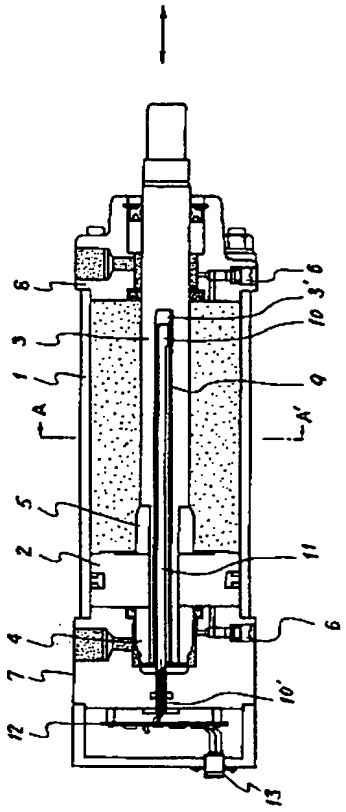
APPLICATION DATE : 24-06-82
APPLICATION NUMBER : 57108687

APPLICANT : MAKOME KENKYUSHO:KK;

INVENTOR : HEGI NOBUHIRO;

INT.CL. : F15B 15/20

TITLE : CYLINDER CONTAINING SCALE THEREWITHIN



ABSTRACT : PURPOSE: To prevent the cylinder from becoming larger and the arrangement from becoming intricate by a structure wherein a hole is provided in a piston rod and a scale and the like are assembled within the hole in a device, in which the cylinder is controlled by measuring the feed of the piston with the scale.

CONSTITUTION: A hole 3' is formed in the rod 3 of a piston 2, which is axially shiftable in a cylinder 1, and a magnetic scale 9 is fixed within the hole 3'. A reading head supporting pipe 11, in which the signal wire 10' of a reading head 10 is past, is fixed to a head cover 7. When the piston 2 is moved right or left, the magnetic scale 9 is moved together with the piston, resulting in causing the relative movement between the magnetic scale 9 and the reading head 10 by the amount same as the displacement amount of the rod 3. Consequently, the reading head 10 reads out the displacement amount of the piston 2 so that said read-out amount is fed-back to a cylinder drive section in order to control the cylinder 1.